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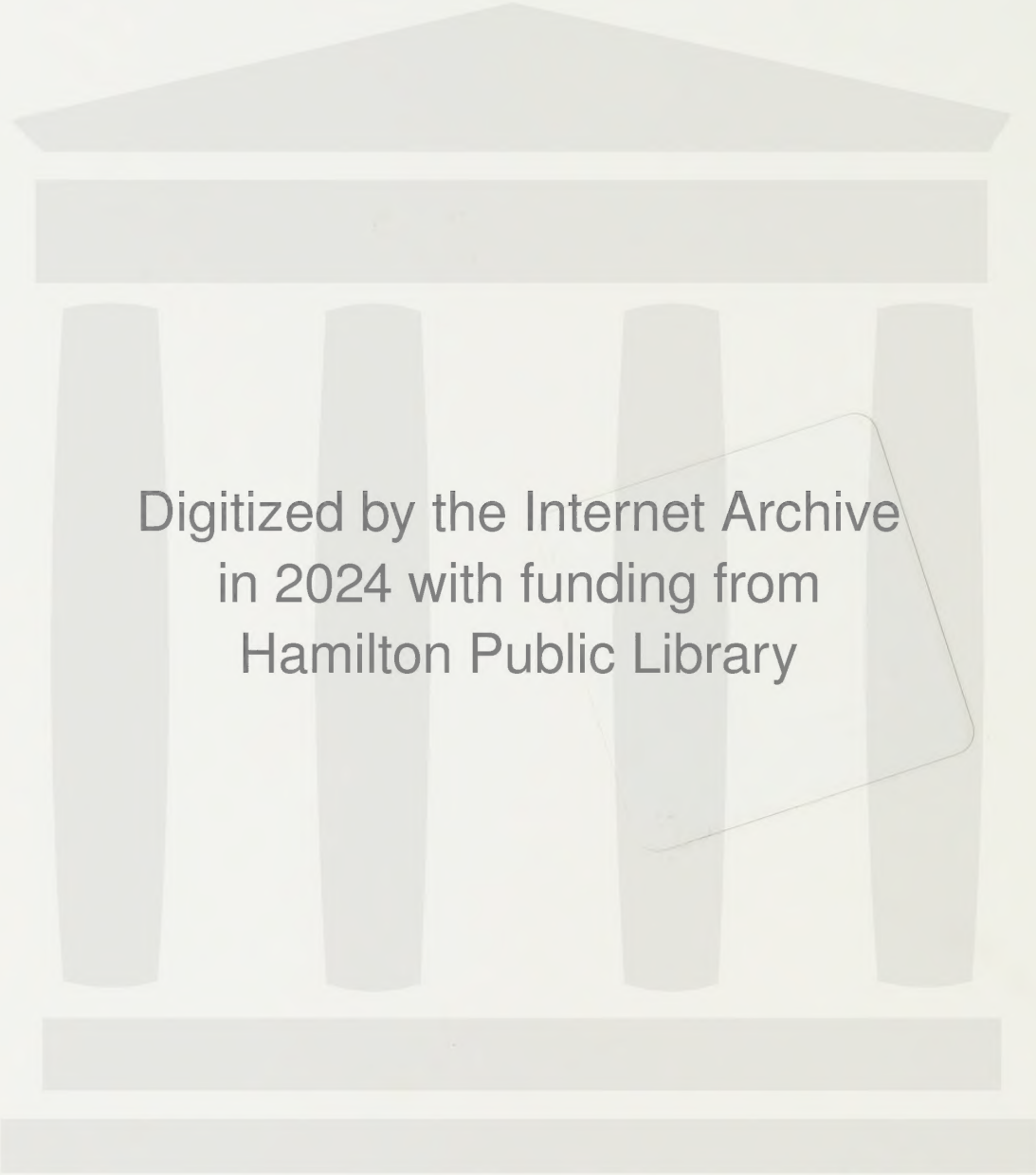
THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

POLLUTION CONTROL PLAN

APPENDICES

A JOINT STUDY BY:

**paul theil associates limited
beak consultants limited**



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LIST OF APPENDICES

- A - FLOW REGULATOR – SUMMARY SHEETS
- B - DETAILED OVERVIEW OF SELECTED FLOW REGULATORS
- C - REPRESENTATIVE CALIBRATION/VALIDATION HYDROGRAPHS
FOR COMBINED SEWER SYSTEM MODEL
- D - KEY PARAMETERS FOR CSO STORAGE OPTIONS
- E - COST ESTIMATE DATA FOR REMEDIAL WORKS
- F - DRAINAGE RATES FOR CSO STORAGE FACILITIES
- G - TECHNICAL EVALUATION OF WOODWARD AVENUE WPCP CONTROL OPTIONS
- H - CONSTITUENT LOADINGS
- I - ADDITIONAL INFORMATION ON CSO QUALITY CHARACTERISTICS

APPENDIX A

FLOW REGULATOR

SUMMARY SHEETS

TABLE 1

MAJOR FLOW REGULATORS WITHIN THE CBD

Flow Regulator	Location	Type	Upstream Impervious Drainage Area (Ha)	Maximum Undiverted Flow (l/s)	Threshold Capacity (l/s/ha)	Direction Of	
						Undiverted Flow	Diverted Flow
1000	Parkdale/ Burlington	2	20	620	30.7	STP	Harbour
1010	Glow/ Parkdale	1	81	300	3.7	STP	Harbour
1030	Melvin/ Woodward	1*	21	320	15.0	2015	Redhill Creek
1040	Parkdale/ Glow	2	50	480	9.6	STP	Harbour
1050	Melvin/ Parkdale	1*	30	920	30.7	1060	1040
1052	Adair/ Queenston	1*	6.3	500	80.0	1050	Redhill Creek
1060	Strathearne /Brampton	3	191	1500	7.9	STP	Harbour
1071	Weir/ Fairfield	1	9.1	250	27.0	2091	1060
1075	Cochrane/ Lawrence	2	44	1800	40.8	1060	4515
1080	Ottawa/ Burlington	1	170	2600	15.3	STP	Harbour

TABLE 1 Cont..d

MAJOR FLOW REGULATORS WITHIN THE CBD

Flow Regulator	Location	Type	Upstream Impervious Drainage Area (Ha)	Maximum Undiverted Flow (l/s)	Threshold Capacity (l/s/ha)	Direction Of	
						Undiverted Flow	Diverted Flow
1100	Main/Edgemont	2	36	180	4.9	1080	3075
1150	Princess/Birch	1*	21	60	2.9	2135	Harbour
1160	Hillyard/Burlington	1, 4*	28	550	20	STP	Harbour
1170	Wentworth/Burton	1*	8	100	12	STP	Harbour
1190	Catharine/Brock	2	7	70	10	STP	Harbour
1200	Ferguson/Wood	1*	37	440	12	2175	Harbour
1210	Wellington Subcatchment	1*	227	900	4.0	2195	Harbour
1220	James/Guise	2*	15	140	9	STP	Harbour
1230	Stuart	1	17	330	19	2180	Harbour
1240	McNabb/Stuart	2 5	14	890	64	STP	1230
1250	Queen/Barton	2 3	30	780	26	STP	Harbour
2015	Dunn/Glow	2	74	240	3.2	1010	Harbour

TABLE 1 Cont..d

MAJOR FLOW REGULATORS WITHIN THE CBD

Flow Regulator	Location	Type	Upstream Impervious Drainage Area (Ha)	Maximum Undiverted Flow (l/s)	Threshold Capacity (l/s/ha)	Direction Of	
						Undiverted Flow	Diverted Flow
2091	McAnulty/ Kenilworth	2	63	330	5.2	080	3075
2130/ 1110	Burlington @ Gage/ Ottawa	5*	183	2200	12	STP	Harbour
2135	Gage/ Burlington	4	239	1940	8.1	STP	Harbour
2165	Rosemary/ Wentworth	3	154	520	3.4	STP	Harbour
2175	Ferguson/ Burlington	3	37	1000	27	STP	Harbour
2195	Ferguson/ Ferrie	3	220	1000	4.5	STP	2175
3075	Beach/ Kenilworth	2	63	300	4.8	STP	Harbour

NOTE: Flow Regulator Types

1. Weir.
 2. Weir with fixed sluice gate and/or orifice plate.
 3. STP-controlled sluice gate with weir.
 4. Drop Pipe from combined sewer to sanitary sewer.
 5. Direct combined sewer discharges to interceptor sewer with no diversions to CSO outfalls.
- * Signifies a lumped flow regulator (i.e. two or more flow regulators modelled as a single regulator)
- Flow Regulator Numbers correspond to either sewer elements (e.g. 2135) or subcatchment inlet numbers (e.g. 1110)

TABLE 2

MAJOR FLOW REGULATORS WITHIN THE CHEDOKE CREEK SEWERSHED

Flow Regulator	Location	Type	Upstream Impervious Drainage Area (Ha)	Maximum Undiverted Flow (l/s)	Threshold Capacity (l/s/ha)	Direction Of	
						Undiverted Flow	Diverted Flow
1460	Wellington /Inverness	2*	17	300	18	1860	Greenhill Tank
1810	Sterling/ Forsythe	1	89	200	2.3	4810	Cootes
1820	Main/Ewan	2	24	130	5.4	1810	Cootes
1830	Royal/ Stroud	3	49	640	13	4800	Chedoke Creek
1860	James/ Mountain	1*	54	750	14	4810	Cootes
4800	Chedoke / 403	3*	279	1400	5.0	STP	Cootes
4810	Glenn/ Tope	3	150	1000	6.7	STP	Cootes

NOTE: Flow Regulator Types

1. Weir.
 2. Weir with fixed sluice gate and/or orifice plate.
 3. STP-controlled sluice gate with weir.
 4. Drop Pipe from combined sewer to sanitary sewer.
 5. Direct combined sewer discharges to interceptor sewer with no diversions to CSO outfalls.
- * Signifies a lumped flow regulator (i.e. two or more flow regulators modelled as a single regulator)
- Flow Regulator Numbers correspond to either sewer elements (e.g. 2135) or subcatchment inlet numbers (e.g. 1110)

TABLE 3

MAJOR FLOW REGULATORS IN THE REDHILL CREEK SEWERSHED

Flow Regulator	Location	Type	Upstream Impervious Drainage Area (Ha)	Maximum Undiverted Flow (l/s)	Threshold Capacity (l/s/ha)	Direction Of	
						Undiverted Flow	Diverted Flow
4515	Lawrence/ King	3	8	130	16	STP	Redhill Creek

NOTE: Flow Regulator Types

1. Weir.
 2. Weir with fixed sluice gate and/or orifice plate.
 3. STP-controlled sluice gate with weir.
 4. Drop Pipe from combined sewer to sanitary sewer.
 5. Direct combined sewer discharges to interceptor sewer with no diversions to CSO outfalls.
- * Signifies a lumped flow regulator (i.e. two or more flow regulators modelled as a single regulator)
- Flow Regulator Numbers correspond to either sewer elements (e.g. 2135) or subcatchment inlet numbers (e.g. 1110)

APPENDIX B

DETAILED OVERVIEW OF SELECTED FLOW REGULATORS

Table 1 lists the flow regulator reviewed in this Appendix and the reason for their review.

Reason for Review of Flow Regulators	Flow Regulators Reviewed
Observed or expected dry weather overflow sites.	Rosemary/Wentworth Birch/Princess Hillyard/Burlington
Flow regulators where simple adjustments to the regulators are expected to decrease CSO frequencies and volumes	Sterling Glen Road/Tope Crescent Chedoke/403 Stuart/McNabb James/Guise Catharine/Brock Beach/Kennilworth

Regulator Location: Rosemary/Wentworth

CSO Outfall: Wentworth

Neighbourhood Map Number: J6

Detailed Plan Number: W-114

Type and Function of Structure: STP Controlled sluice gate with weir.

Overview:

A field investigation suggests the following:

1. The overflow weir may be too low to prevent dry weather overflows.
2. The sanitary sewer which conveys flows from the regulator has the capacity to convey additional flow.

Suggested Works:

Increase the height of the overflow weir.

Difficulty Level of Suggested Works: Moderate

Comments:

1. Currently, approximately 520 l/s can be conveyed from the regulator without CSO's.
2. The capacity of the sanitary sewer downstream of the regulatory (a 32" (800 mm) sewer at 0.2 percent) is approximately 600 l/s.
3. Region staff were scheduled to increase the height of the overfall weir in the fall of 1989.
4. Dry weather overflows of sanitary sewage must be eliminated.

Regulator Location: Birch/Princess

CSO Outfall: Birch

Neighbourhood Map Number: J-7

Detailed Plan Number: B-89

Type and Function of Structure: Weir

Overview:

A field investigation suggests the following:

1. The overflow weir is too low to prevent dry weather overflows.
2. Sewage flows at the regulator and in the 24" combined sewer which conveys flows from the regulator (to Gibson Avenue) are slow and stagnant. Sewage flows are quicker east of Gibson Avenue. These observations suggest the 24" combined sewer from Birch to Gibson may be blocked, or may have settled to a flatter grade over the years.

Suggested Works:

1. Check pipe for blockage and clean if possible.
2. Replace approximately 75 m of combined sewer on Princess from Birch to Gibson if necessary.

Difficulty Level of Suggested Works: Moderate if only cleaning is required.

Comments:

Dry weather overflows of sanitary sewage must be eliminated.

Regulator Location: Hillyard/Burlington

CSO Outfall: Wentworth

Neighbourhood Map Number: J-5

Detailed Plan Number: H-47 (drop pipe structure details only)

Type and Function of Structure: Drop pipe from combined sewer to sanitary sewer.

Overview:

A field investigation suggest the following:

1. The 18" outfall pipe on Hillyard (north of Burlington) has no weir/control structure to regulate CSO and, consequently, dry weather overflows may occur.
2. The 21" outfall that starts at Hillyard/Burlington and runs west may be entirely (purposely) blocked.

Suggested Works:

1. If the 18" line on Hillyard (north of Burlington) is a CSO outfall, rather than a combined sewer, construct a weir at its entrance to regulate CSO and to estimate dry weather overflows.

Difficulty Level of Suggested Works: Moderate

Comments:

Dry weather overflows must be eliminated. Region staff were scheduled to investigate this area in late 1989.

Regulator Location: Sterling (80 m east of Forsythe by Creek)

CSO Outfall: Sterling

Neighbourhood Map Number: C-10

Detailed Plan Number: S-89

Type and Function of Structure: Weir

Overview:

A field investigation indicated the items below:

1. The overflow weir extends to the obvert of the existing 24" combined sewer.
2. A rock or concrete block is lodged in the 24" combined sewer. This restricts the capacity of the 24" sewer and produces a backwater effect into the flow regulator.

Suggested Works:

Remove the rock/concrete block from the combined sewer to increase the undiverted flow capacity of the regulator and to decrease CSO volumes.

Difficulty Level of Suggested Works: Moderate

Comments:

Regional staff were scheduled to remove the obstruction in the fall of 1989.

Regulator Location: Glen Road/Tope Crescent

CSO Outfall: King

Neighbourhood Map Number: E9

Detailed Plan Number: –

Type and Function of Structure: STP – controlled sluice gate with weir

This structure routes sewage to the western interceptor and diverts excess flows to the King outfall.

Overview:

A field investigation indicated the items below:

1. The overflow weir has a height of 13 ½ ".
2. In the open position, the STP controlled sluice gate is 24 " above the invert of the 36" sanitary sewer.
3. The sanitary interceptor downstream of this regulator generally has unused capacity/storage for events smaller than 12 mm in depth.

CSO's could be reduced at the King outfall by directing more flows into the interceptor.

Suggested Works: Raise the height of the overflow weir.

Difficulty Level of Suggested Works: Moderate

Comments:

The capacity of the 36" sanitary interceptor downstream of this flow regulator is unknown due to a lack of slope information. The analysis assumes an overflow threshold of 1.0 and 1.25 m³/s for existing and improved conditions, respectively.

This outfall is located in a human contact area (i.e. parkland).

Regulator Location: Chedoke/403 (east side of Highway 403)

CSO Outfall: Dundurn

Neighbourhood Map Number: E9

Detailed Plan Number: –

Type and Function of Structure: STP–controlled sluice gate with weir.

This structure routes sewage to the western interceptor and diverts excess flows to the Dundurn outfall.

Overview:

A detailed field investigation of this structure was not possible due to site limitations. However, based on downstream flow monitoring results and system knowledge, it was assumed the height of the overflow weir could be raised to double the inflow to the western interceptor.

Suggested Works:

Raise the height of the overflow weir.

Difficulty Level of Suggested Works: Moderate

Comments:

The Dundurn outfall is located by a human contact area (i.e. park land).

Regulator Location: Stuart/McNabb

CSO Outfall: Hess

Neighbourhood Map Number: G-7

Detailed Plan Number: -

Type and Function of Structure: Weir with fixed sluice gate.

Overview:

This structure diverts combined sewage to the western interceptor through a 15" sewer. A field survey indicates the sluice gate covers half of the 15" sewer. Combined sewer overflow volumes at the downstream Stuart Street regulator (Hess outfall) could be reduced by directing more sewage to the western interceptor.

Suggested Works:

Adjust the sluice gate to allow more flow to be conveyed to the sanitary interceptor.

Difficulty Level of Suggested Works: Moderate

Comments:

Adjustment may not be required as the Region has plans to construct a CSO storage facility downstream of the regulator.

Regulator Location: James/Guise

CSO Outfall: James

Neighbourhood Map Number: G-5

Detailed Plan Number: 87-S-37

Type and Function of Structure: Weir with fixed sluice gate.

Overview:

A field survey indicates the sluice gate exposes only one-third of the 375 mm (15") sanitary line that conveys flow to the sanitary interceptor. This branch of the sanitary interceptor appears to have minimal inflows and, consequently, CSO volumes may be reduced by directing more combined sewage flow to the sanitary interceptor.

Suggested Works:

Adjust the sluice gate to allow more flow to be conveyed to the sanitary interceptor. Overflow weir height could also be raised.

Difficulty Level of Suggested Works: Moderate

Comments:

This outfall is located in a human contact area (i.e. Marina).

Regulator Location:	Catharine/Brock
CSO Outfall:	Catharine
Neighbourhood Map Number:	H-5
Detailed Plan Number:	72-S-367
Type and Function of Structure:	Weir with fixed sluice gate.

Overview:

A filed survey indicates the sluice gate exposes only one-third of the 15/18" sanitary line that conveys flow the sanitary interceptor. This branch of the sanitary interceptor appears to have minimal inflows and, consequently, CSO volumes may be reduced by directing more combined sewage flow to the sanitary interceptor.

Suggested Works:

Adjust the sluice gate to allow more flow to be conveyed to the sanitary interceptor. Overflow weir height could also be raised.

Difficulty Level of Suggested Works:	Moderate
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Comments:

This outfall is located in a human contact area.

Regulator Location: Beach/Kennilworth

CSO Outfall: Kennilworth

Neighbourhood Map Number: N-6

Detailed Plan Number: 85-S-54

Type and Function of Structure: Overflow weir and orifice plate.

Overview:

1. Current position of orifice plate (i.e. on the 200 mm drop pipe, Drawing 85-S-54) is unknown.
2. Downstream sanitary sewer (i.e. the Western interceptor) may be able to accept additional inflow from regulator.

Suggested Works:

1. Fully open the orifice plate.

Difficulty Level of Suggested Works: Moderate

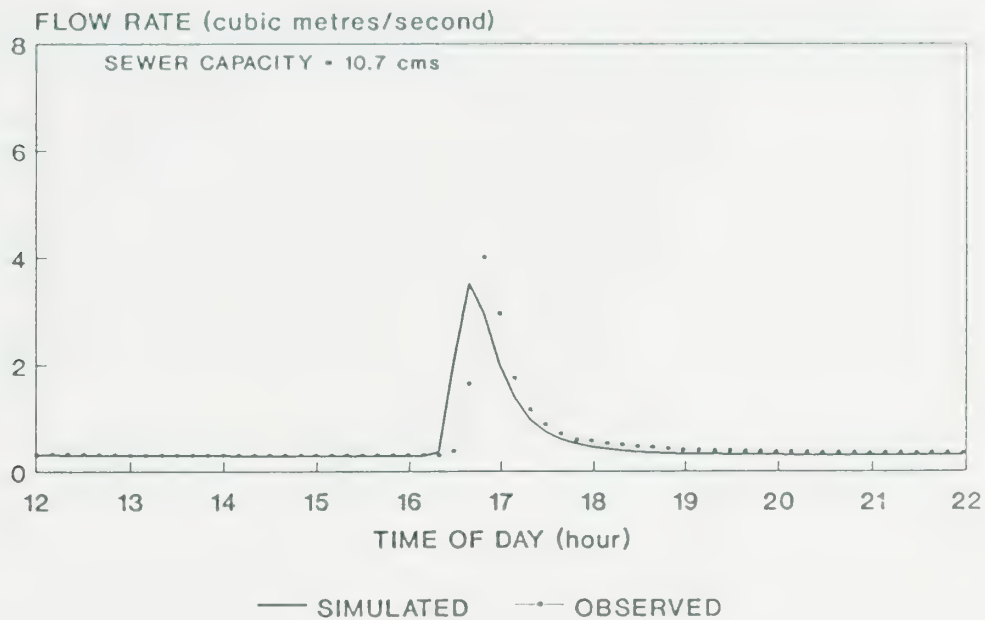
Comments: None

APPENDIX C

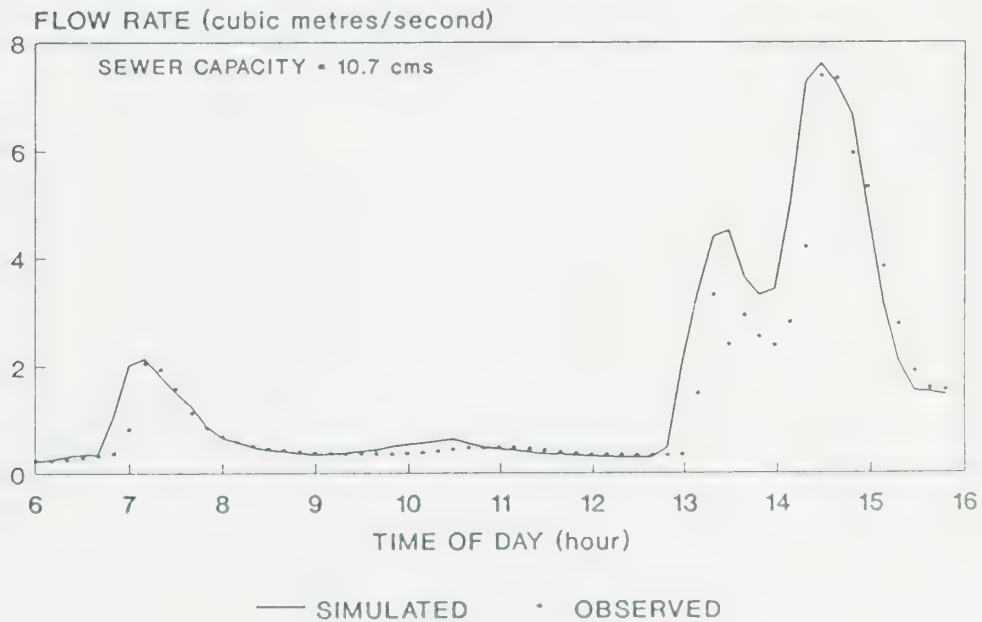
REPRESENTATIVE CALIBRATION/VALIDATION HYDROGRAPHS

FOR COMBINED SEWER SYSTEM MODEL

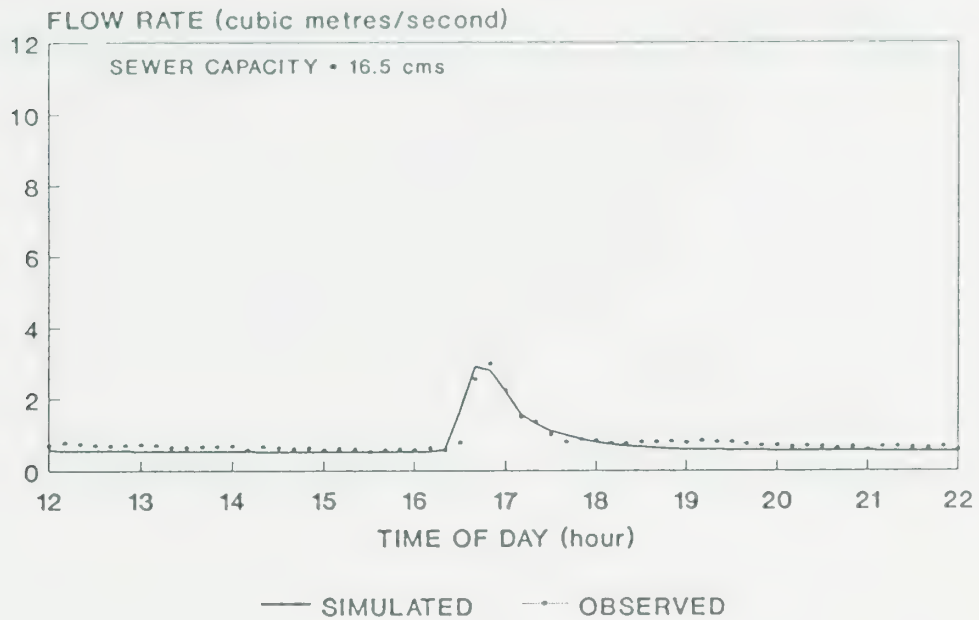
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STRATHEARNE COMBINED SEWER @ VANSITMART



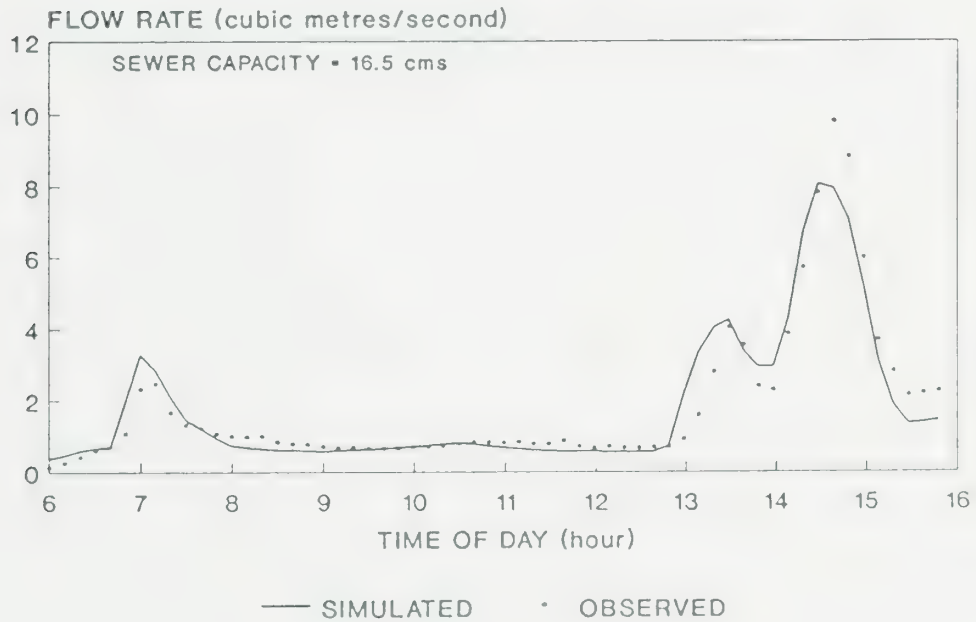
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STRATHEARNE COMBINED SEWER @ VANSITMART



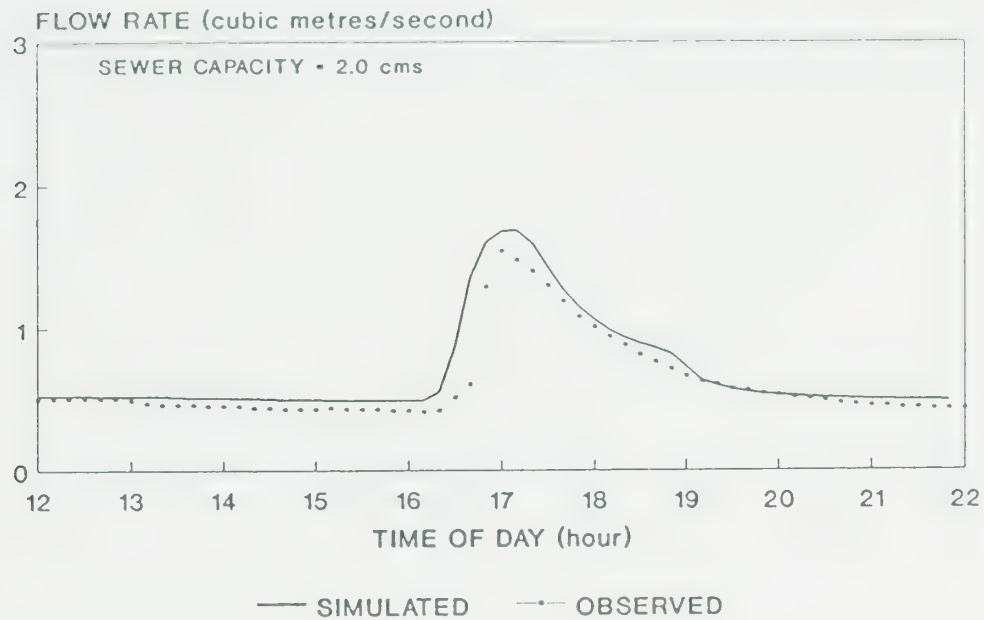
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FENNEL AVE COMBINED SEWER @ EAST 25TH



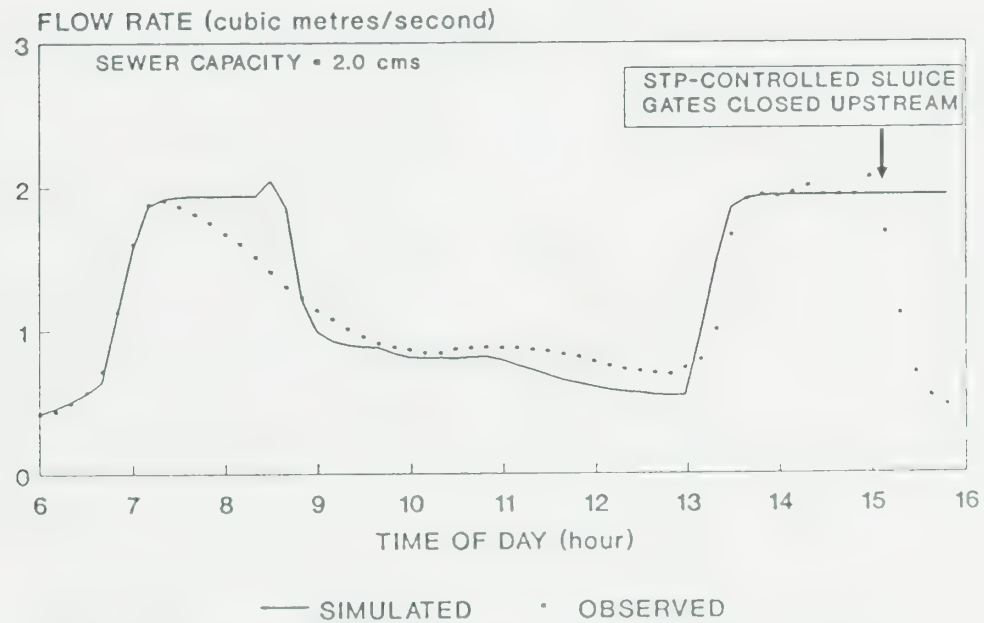
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FENNEL AVE COMBINED SEWER @ EAST 25TH



CALIBRATION EVENT: JULY 27, 1989
SANITARY INTERCEPTOR AT QUEEN AND BARTON



VALIDATION EVENT: SEPTEMBER 1, 1989
SANITARY INTERCEPTOR AT QUEEN AND BARTON



NOTE: STP-CONTROLLED SLUICE GATE CLOSURES NOT MODELLED

APPENDIX D

KEY PARAMETERS FOR

CSO STORAGE OPTIONS

TABLE 1

KEY PARAMETERS FOR STORAGE OPTION #1
SEPARATE OFFLINE STORAGE FACILITIES AT EACH OUTFALL

Type of Storage and Outfall	4 CSO/Year Control Strategy						1 CSO/Year Control Strategy					
	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost
Melvin	26.5	5,500	1.32	0.13	0.003	1.323	34.0	9,000	1.80	0.19	0.004	1.804
Queenston	16.0	2,000	0.60	0.07	0.002	0.602	20.0	3,000	0.90	0.09	0.002	0.902
Lawrence	35.0	9,500	1.90	0.20	0.004	1.904	47.5	17,500	2.98	0.33	0.007	2.987
Greenhill	69.0	37,000	5.92	0.62	0.013	5.933	120.5	114,000	18.24	1.70	0.034	18.274
Royal	37.0	10,500	2.00	0.22	0.055	2.055	49.5	19,000	3.23	0.35	0.088	3.318
Ewan	30.0	7,000	1.47	0.31	0.006	1.476	37.5	11,000	2.09	0.38	0.008	2.098
Sterling	45.5	16,000	2.88	0.31	0.016	2.896	55.0	23,500	4.00	0.42	0.021	4.021
King	40.0	12,500	2.25	0.25	0.069	2.319	51.5	20,500	3.49	0.38	0.105	3.595
Dundurn	81.0	51,000	8.16	0.83	0.229	8.389	98.5	75,500	12.08	1.18	0.325	12.405
Queen	28.0	6,000	1.38	0.14	0.028	1.408	34.0	9,000	1.71	0.19	0.038	1.758
Hess	24.0	4,500	1.17	0.12	0.024	1.194	28.0	6,000	1.32	0.14	0.028	1.348
James	20.0	3,000	0.90	0.09	0.077	0.977	24.0	4,500	1.17	0.12	0.096	1.266
Catharine	18.0	2,500	0.75	0.08	0.016	0.766	21.5	3,500	1.05	0.10	0.020	1.070
Ferguson & Wellington	63.5	31,500	5.04	0.54	0.432	5.472	77.0	46,500	7.44	0.76	0.608	8.048
Wentworth	74.0	43,000	6.88	0.71	0.568	7.448	90.5	64,000	10.24	1.01	0.808	11.048
Birch	30.0	7,000	1.47	0.16	0.128	1.598	37.0	10,500	2.00	0.22	0.176	2.176
Plymouth	90.5	64,000	10.24	1.01	0.808	11.048	111.0	96,500	14.48	1.46	1.168	15.648
Ottawa	32.0	8,000	1.64	0.18	0.144	1.784	43.0	14,500	2.61	0.28	0.224	2.834
Kennilworth	59.5	27,500	4.54	0.48	0.384	4.929	73.0	41,500	6.64	0.69	0.552	7.192
Starthearne	68.5	36,500	5.84	0.62	0.496	6.336	85.0	56,500	9.04	0.90	0.720	9.760
Parkdale	47.5	17,500	2.98	0.33	0.264	3.244	60.0	28,000	4.76	0.49	0.392	5.152
Dunn	45.5	16,000	2.80	0.31	0.248	3.048	55.0	23,500	4.00	0.42	0.336	4.336
TOTALS (Rounded)		418,000	72.1	7.7	4.0	76.1	-	697,500	115.3	11.8	5.8	121.1

TABLE 2

KEY PARAMETERS FOR STORAGE OPTION #2

OFFLINE STORAGE FACILITIES WITH SOME LUMPED FACILITIES

Type of Storage and Outfall	4 CSO/Year Control Strategy						1 CSO/Year Control Strategy					
	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost
Melvin	26.5	5,500	1.32	0.13	0.003	1.323	34.0	9,000	1.80	0.19	0.004	1.804
Queenston	16.0	2,000	0.60	0.07	0.002	0.602	20.0	3,000	0.90	0.09	0.002	0.902
Lawrence	35.0	9,500	1.90	0.20	0.004	1.904	47.5	17,500	2.98	0.33	0.007	2.987
Greenhill	69.0	37,000	5.92	0.62	0.013	5.933	111.0	96,500	15.44	1.46	0.030	15.470
Royal	37.0	10,500	2.00	0.22	0.055	2.055	49.5	19,000	3.23	0.35	0.088	3.318
Ewan	30.0	7,000	1.47	0.36	0.006	1.476	37.5	11,000	2.09	0.38	0.008	2.098
Sterling	45.5	16,000	2.88	0.31	0.016	2.896	55.0	23,500	4.00	0.42	0.021	4.021
King & Dundurn	90.0	63,500	10.16	1.00	0.275	10.44	111.0	96,000	15.36	1.46	0.402	15.762
Queen & Hess	37.0	10,500	2.00	0.22	0.044	2.044	44.0	15,000	2.70	0.29	0.058	2.758
James, Catharine, Fergusson & Wellington	70.0	37,000	5.92	0.64	0.128	6.048	83.5	54,500	8.72	0.87	0.174	8.894
Wentworth	74.0	43,000	6.88	0.71	0.568	7.448	90.5	64,000	10.24	1.01	0.808	11.048
Birch	30.0	7,000	1.47	0.16	0.128	1.598	37.0	10,500	2.00	0.22	0.176	2.176
Plymouth	90.5	64,000	10.24	1.01	0.808	11.048	111.0	96,500	14.48	1.46	1.168	15.648
Ottawa	32.0	8,000	1.64	0.18	0.144	1.784	43.0	14,500	2.61	0.28	0.224	2.834
Kennilworth	59.5	27,500	4.54	0.48	0.384	4.929	73.0	41,500	6.64	0.69	0.552	7.192
Starthearne	68.5	36,500	5.84	0.62	0.496	6.336	85.0	56,500	9.04	0.90	0.720	9.760
Parkdale	47.5	17,500	2.98	0.33	0.264	3.244	60.0	28,000	4.76	0.49	0.392	5.152
Dunn	45.5	16,000	2.80	0.31	0.248	3.048	55.0	23,500	4.00	0.42	0.336	4.336
TOTALS (Rounded)		418,000	70.5	7.5	3.7	74.2	-	697,500	113.8	11.6	5.2	119.0

TABLE 3

KEY PARAMETERS FOR OPTION #3

OFFLINE STORAGE FACILITIES AND INLINE STORAGE
FROM THE WOODWARD AVENUE STP TO GAGE AVENUE

Type of Storage and Outfall	4 CSO/Year Control Strategy						1 CSO/Year Control Strategy					
	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost
Offline												
Melvin	26.5	5,500	1.32	0.13	0.003	1.323	34.0	9,000	1.80	0.19	0.004	1.804
Queenston	16.0	2,000	0.60	0.07	0.002	0.602	20.0	3,000	0.90	0.09	0.002	0.902
Lawrence	35.0	9,500	1.90	0.20	0.004	1.904	47.5	17,500	2.98	0.33	0.007	2.987
Greenhill	69.0	37,000	5.92	0.62	0.013	5.933	111.0	114,000	18.24	1.70	0.034	18.274
Royal	37.0	10,500	2.00	0.22	0.055	2.055	49.5	19,000	3.23	0.35	0.088	3.318
Ewan	30.0	7,000	1.47	0.31	0.006	1.476	37.5	11,000	2.09	0.23	0.008	2.098
Sterling	45.5	16,000	2.88	0.31	0.016	2.896	55.0	23,500	4.00	0.42	0.021	4.021
King & Dundurn	90.0	63,500	10.16	1.0	0.275	10.44	111.0	96,000	15.36	1.46	0.402	15.762
Queen & Hess	37.0	10,500	2.00	0.22	0.044	2.044	44.0	15,000	2.70	0.29	0.058	2.758
James, Catharine, Ferguson & Wellington	70.0	37,000	5.92	0.64	0.128	6.048	83.5	54,500	8.72	0.87	0.174	8.894
Wentworth	74.0	43,000	6.88	0.71	0.568	7.448	90.5	64,000	10.24	1.01	0.808	11.048
Birch	30.0	7,000	1.47	0.16	0.128	1.598	37.0	10,500	2.00	0.22	0.176	2.176
Tunnel												
Plymouth	Volume = 169,500 m ³						Volume = 260,500 m ³					
Ottawa	Length = 4.5 km						Length = 4.5 km					
Kennilworth	Diameter = 7.0 m						Diameter = 9.0 m					
Starthearne						Cost = 52.0						Cost = 65.0
Parkdale	Land costs assumed to be negligible as tunnel will be located under existing roads and easements.						Land costs assumed to be negligible as tunnel will be located under existing roads and easements.					
Dunn												
TOTALS (Rounded)	-	418,000	42.5	4.5	1.3	95.8	-	697,000	72.3	7.2	1.8	139.1

KEY PARAMETERS FOR STORAGE OPTION #4

OFFLINE STORAGE FACILITIES AND INLINE STORAGE FROM THE WOODWARD AVENUE STP TO WENTWORTH AVENUE

Type of Storage and Outfall	4 CSO/Year Control Strategy						1 CSO/Year Control Strategy					
	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost
Offline	26.5	5,500	1.32	0.13	0.003	1.323	34.0	9,000	1.80	0.19	0.004	1.804
Melvin	16.0	2,000	0.60	0.07	0.002	0.602	20.0	3,000	0.90	0.09	0.002	0.902
Queenston	35.0	9,500	1.90	0.20	0.004	1.904	47.5	17,500	2.98	0.33	0.007	2.987
Lawrence	69.0	37,000	5.92	0.62	0.013	5.933	111.0	114,000	18.24	1.70	0.034	18.274
Greenhill	37.0	10,500	2.00	0.22	0.055	2.055	49.5	19,000	3.23	0.35	0.088	3.318
Royal	30.0	7,000	1.47	0.31	0.006	1.476	37.5	11,000	2.09	0.23	0.008	2.098
Ewan	45.5	16,000	2.88	0.31	0.016	2.896	55.0	23,500	4.00	0.42	0.021	4.021
Sterling	90.0	63,500	10.16	1.00	0.275	10.44	111.0	96,000	15.36	1.46	0.402	15.762
King & Dundurn	37.0	10,500	2.00	0.22	0.044	2.044	44.0	15,000	2.70	0.29	0.058	2.758
Queen & Hess	70.0	37,000	5.92	0.64	0.128	6.048	83.5	54,500	8.72	0.87	0.174	8.894
James, Catharine, Ferguson & Wellington												
Tunnel	Volume = 219,500 m ³ Length = 6.2 km Diameter = 7.0 m						Volume = 335,000 m ³ Length = 6.2 km Diameter = 8.5 m					
Wentworth												
Birch												
Plymouth												
Ottawa												
Kennilworth												
Starthearne												
parkdale												
Dunn												
TOTALS (Rounded)	-	418,000	34.2	3.6	0.9	106.1	-	697,000	60.0	6.5	0.8	147.6

KEY PARAMETERS FOR STORAGE OPTION #5

OFFLINE STORAGE FACILITIES AND INLINE STORAGE
FROM THE WOODWARD AVENUE STP TO HIGHWAY 403

Type of Storage and Outfall	4 CSO/Year Control Strategy						1 CSO/Year Control Strategy					
	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost	Tank Dia. (m)	Tank Volume (m ³)	Tank Cost	Land Area (ha)	Land Cost	Total Cost
Offline												
Melvin	26.5	5,500	1.32	0.13	0.003	1.323	34.0	9,000	1.80	0.19	0.004	1.804
Queenston	16.0	2,000	0.60	0.07	0.002	0.602	20.0	3,000	0.90	0.09	0.002	0.902
Lawrence	35.0	9,500	1.90	0.20	0.004	1.904	47.5	17,500	2.98	0.33	0.007	2.987
Greenhill	69.0	37,000	5.92	0.62	0.013	5.933	111.0	114,000	18.24	1.70	0.034	18.274
Royal	37.0	10,500	2.00	0.22	0.055	2.055	49.5	19,000	3.23	0.35	0.088	3.318
Ewan	30.0	7,000	1.47	0.31	0.006	1.476	37.5	11,000	2.09	0.23	0.008	2.098
Sterling	45.5	16,000	2.88	0.31	0.016	2.896	55.0	23,500	4.00	0.42	0.021	4.021
Queen & Hess	37.0	10,500	2.00	0.22	0.044	2.044	44.0	15,000	2.70	0.29	0.058	2.758
James, Catharine, Ferguson & Wellington	70.0	37,000	5.92	0.64	0.128	6.048	83.5	54,500	8.72	0.87	0.174	8.894
Tunnel												
King	Volume = 283,000 m ³						Volume = 431,000 m ³					
Dundurn	Length = 11.2 km						Length = 11.2 km					
Wentworth	Diameter = 6.0 m						Diameter = 7.0 m					
Birch												
Plymouth												
Ottawa												
Kennilworth												
Starthearne												
Parkdale												
Dunn												
TOTALS (Rounded)	-	418,000	24.0	3.0	0.3	136.3	-	697,500	44.7	4.9	0.9	174.6

APPENDIX E

COST ESTIMATE DATA

FOR REMEDIAL WORKS

APPENDIX E

COST ESTIMATE DATA FOR REMEDIAL WORKS

Cost Estimates for CSO Storage Facilities

Preliminary cost estimates were established for the alternatives described in Section 9 using the data presented here. In general, the cost estimates were based on unit costs as determined from other studies of a similar nature. Further description as to the method used for estimating costs is given below for each of the major components. All estimates include 20 percent engineering and contingency allowance. Estimates were updated to reflect late 1990 values.

Tunnel Construction Cost

Three recent studies (R.V. Anderson, 1990, Marshall, Macklin & Monaghan, 1990, Canviro, 1990) established tunnelling costs for various sewer (tunnel) diameters, depths and ground conditions. The results of these studies were plotted (Figure 1) and an average value was selected for a given diameter.

Construction Costs for Storage Facilities

Construction cost estimates for storage facilities were based on two studies (TAWMS, 1984, Canviro, 1988) and from details of the Greenhill facility within the City of Hamilton and the eastern beaches tank in the City of Toronto. Collectively these studies provided estimates for a range of sizes (i.e. 2,000 m³ to 70,000 m³). A best-fit estimate was then established based on the various estimates (Figure 2).

Land Costs

The estimated cost to purchase land for any proposed storage facilities was carried out by:

- selecting likely sites for proposed facilities;
- requesting estimated land values for each site from engineering staff at the Regional office.

The estimated land value costs range from \$20,000/ha to \$1,000,000/ha and are summarized in Table 1.

FIGURE 1: TUNNEL CONSTRUCTION COSTS

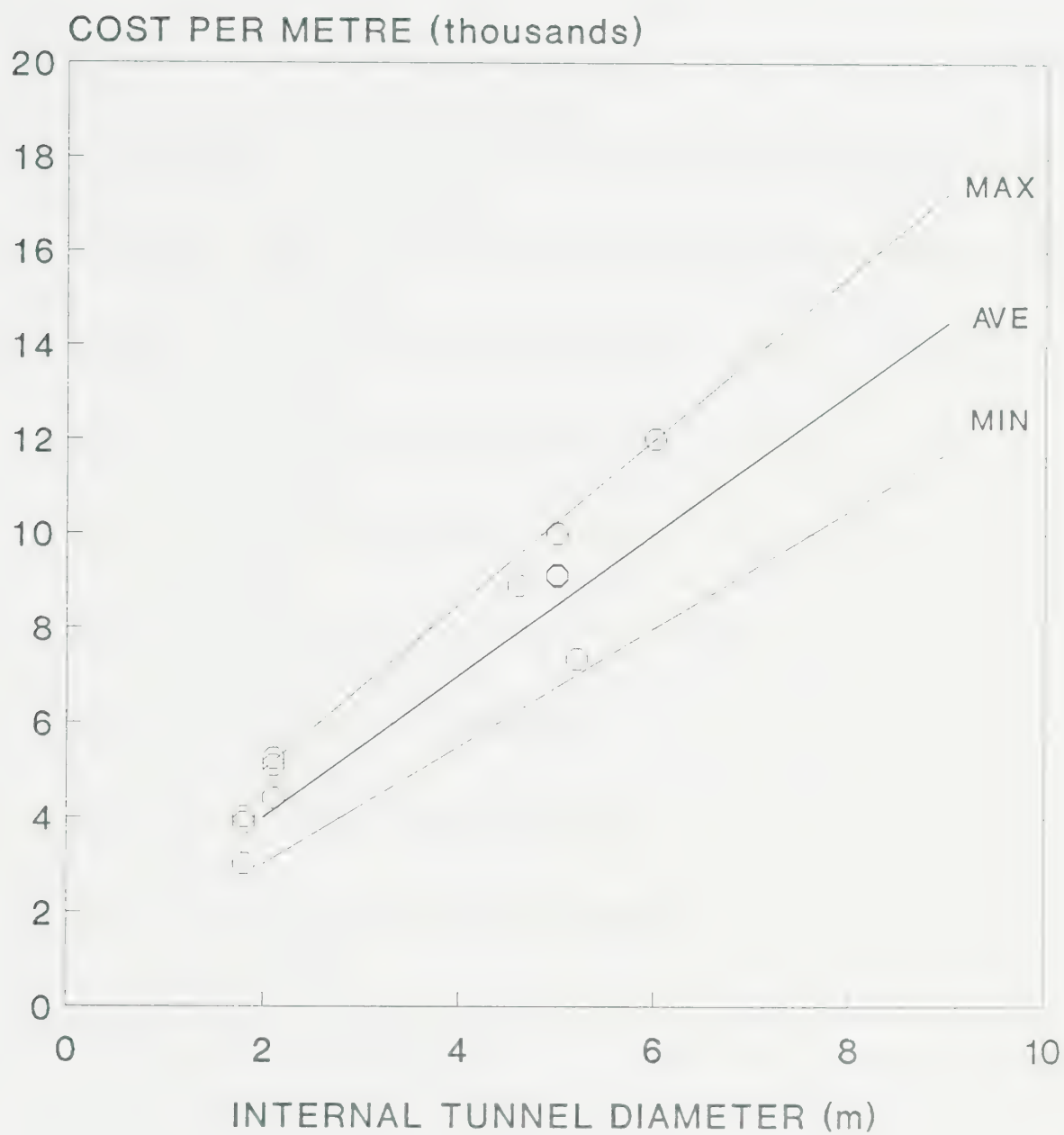


FIGURE 2: CONSTRUCTION COSTS FOR
REINFORCED CONCRETE TANKS

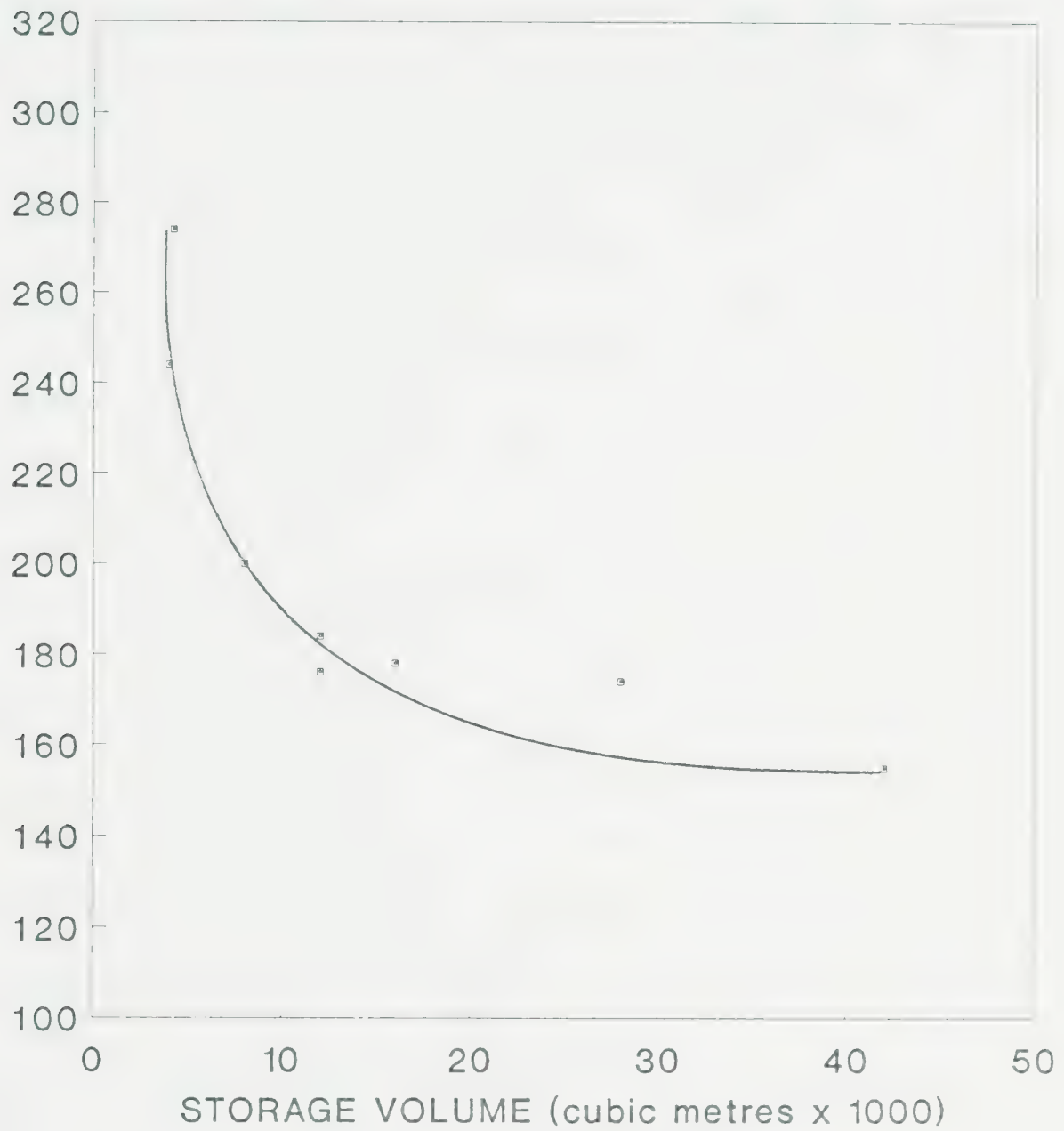


TABLE 1
POTENTIAL SITES AND LAND COSTS FOR OFFLINE COMBINED SEWER
OVERFLOW STORAGE FACILITIES

Neighbourhood Map Number	General Description	CSO Outfalls Which May Be Stored At Site	Estimated Land Cost Per Hectare *
–	Industrial/commercial lands (i.e. parking lots) in the Barton/Burlington Street area from the James Street outfall to the Dunn Avenue outfall.	All outfalls along waterfront between James and Dunn.	\$800,000
106	Parklands south of Dock Service Road and north of Burlington Street.	James, Catharine Ferguson and Wellington	Easement \$200,000
02	Parklands east of Royal Avenue/Stroud Road.	Royal	Easement \$250,000
03	HEPC lands northwest of Main Street and Ewen Road	Ewan	McMaster Easement \$20,000 Highlands \$1,000,000
88	Parkland by the existing Greenhill Avenue CSO storage facility.	Greenhill	Easement \$20,000
136	Ravine lands north/south of Sterling Avenue.	Sterling	Easement \$50,000
51/99/113	Lands in the Redhill Creek Valley	Queenston, Melvin and Lawrence	Easement \$20,000
127	Lands with Victoria Park	King and Dundurn	Easement \$300,000
127	Open space south of King Street, north of Main Street and west of Dundurn.	King and Dundurn	Easement \$250,000
107	Lands by the Simcoe/Strachan Street pumphouse where the proposed CSO storage facility will be constructed.	Queen and Hess	Easement \$200,000

* Land costs supplied by the Regional Municipality of Hamilton–Wentworth.

Cost Estimation for Wastewater Treatment Plant

CAPDET is a Computer Assisted Procedure for the design and evaluation of wastewater treatment systems. This program is primarily a planning tool which permits the evaluation of specific or alternative treatment trains on a performance/cost basis. For this study, only the cost estimation capabilities of the CAPDET program were of particular use as other, more sophisticated, computer simulation procedures were used to identify the appropriate plant expansion requirements.

In order to have cost estimates calculated by the CAPDET program, the model of the treatment plant comprising the expanded Woodward Avenue WPCP was coded into the program. The treatment train model was simplified by disregarding the complexities of a branched plant (new side and old side) and considering only the total primary clarification surface area, the total aeration volume and the total secondary clarification surface area of the expansion. Thus, the treatment train for each of the two scenarios comprised:

	<u>Scenario 1</u>	<u>Scenario 2</u>
	1 Overflow/Year	4 Overflows/Year
Preliminary Treatment	Expand	Expand
Primary Clarification	120,000 ft ²	104,000 ft ²
Aeration	5.8 MG (US)	5.8 MG (US)
	Mechanical	Mechanical
Secondary Clarification	139,000 ft ²	117,000 ft ²
Chlorination	No Change	No Change
Anaerobic Sludge Digestion	No Change	No Change

Cost estimation was based on values for material costs (incorporated into the program) and parametric cost estimation equations (also incorporated into the program). The default values are correct for the base year reflected by the value of the Marshall and Swift Cost Estimating Index (577.0). Current costs for each train were estimated by applying the multiplication factor formed by the ratio of the latest available Marshall and Swift Index (917.9 for 3rd quarter 1990) and that for establishing the current values for the many unit material costs required by the CAPDET program.

The plant expansion estimates incorporate the effect of a 50 percent engineering and contingency allowance which accounts for the anticipated difficulties in retrofitting proposed tankage to existing tankage. This allowance (50 percent) was arbitrarily established at this preliminary costing stage and would require a more detailed review for firmer refinement after completion of the recommended plant planning study. Cost estimates for the high lift pumps were established by telephoning equipment suppliers while cost estimates for the equalization tank was based upon \$160/cubic metre of storage volume.

APPENDIX F

DRAINAGE RATES FOR CSO STORAGE FACILITIES

APPENDIX F

DRAINAGE RATES FOR CSO STORAGE FACILITIES

Introduction

This Appendix discusses the influence of CSO storage facility drainage rates on the level of CSO control obtained by such facilities. The analysis is based on CSO patterns at the representative Strathearne Avenue CSO outfall sewershed and includes:

1. An analysis of storage tanks sized for both the 4 and 1 CSO events/year control strategies.
2. Analyses during the typical (1989) and wet (1981) years to illustrate the estimated average and minimum levels of control which would be attained by the facilities.

Analysis

The size of a CSO storage facility is dependent on two factors, namely:

- the level of CSO control required; and
- the rate at which the combined sewage in the facility is to be drained back to the sanitary system.

The first point was addressed in Section 9 by sizing the CSO storage facilities using either a 1 CSO/year or a 4 CSO year control strategy. The second point also influences the effectiveness of a facility since CSO's may occur for small or medium sized rainfall events if a facility has not been drained quickly enough to provide sufficient storage for subsequent events. CSO storage facility "draw-down" time is, therefore, an important issue which must be addressed.

Storage facility draw-down time itself is influenced by:

- the interevent time between rainfall events; and
- the ability of the WPCP to treat stored sewage.

These factors will determine, along with tank size, the level of CSO control obtained by any proposed CSO storage plan.

An estimate of appropriate draw-down times was made by considering the points outlined below.

1. The average interevent time between rainfall events is approximately 3.5 days, assuming a minimum 24 hour interevent time.
2. Under existing conditions, rainfall events increase WPCP inflows for a period of 0.5 to 1.0 days (Section 4).

Therefore, on average, the maximum time available to treat stored CSO's varies from approximately 2.5 to 3.0 days if it is assumed that all stored sewage is to be treated before the next rainfall event occurs. However, it may also be feasible to treat stored CSO's for a period longer than the interevent time between rainfall events. Tank drawdown rates of 2, 3, 4 and 5 days were, therefore, considered. Both the typical (1989) and wet (1981) year were considered in the analysis. The analysis focused on the representative Strathearne CSO outfall sewershed. Results are listed in Table 1.

A review of Table 1a indicates the level of CSO control obtained by the proposed 1 and 4 CSO/year tanks brackets the required level of constituent loading reduction during a typical year as outlined in the RAP documents. Also evident from Table 1 is that the level of CSO control obtained from an off-line storage facility is not overly sensitive to the drainage rate of the facility. This is an important observation since fast drainage rates will require more WPCP expansion to treat CSO inflows than slow drainage rates.

Table 1b indicates the level of CSO control that would be attained by the proposed storage facilities during a wet (1981) year. Generally, the proposed 1 and 4 CSO/year control strategies can be expected to provide 80 and 70 percent CSO volume control, respectively. These values represent the minimum level of CSO control that the proposed storage facilities are expected to provide.

TABLE 1
INFLUENCE OF CSO STORAGE FACILITY DRAINAGE RATE
ON CSO CHARACTERISTICS

a) Typical (1989) Year

Conditions	Number of CSO Events	CSO Volume (m ³)*	Percent Reduction in CSO Volume
Existing	27	309,000	–
Proposed 1 CSO/Year Tank			
–With 5 day Drainage Rate	1	14,800	95
–With 4 day Drainage Rate	1	14,000	95
–With 3 day Drainage Rate	1	13,300	95
–With 2 day Drainage Rate	1	11,700	96
Proposed 4 CSO/Year Tank			
–With 5 day Drainage Rate	3	41,700	86
–With 4 day Drainage Rate	2	40,600	87
–With 3 day Drainage Rate	2	39,700	87
–With 2 day Drainage Rate	2	37,900	88

* CSO volume under existing conditions and CSO tank overflow volumes under proposed conditions

b) Wet (1981) Year

Conditions	Number of CSO Events	CSO Volume (m ³)*	Percent Reduction in CSO Volume
Existing	35	663,000	–
Proposed 1 CSO/Year Tank			
–With 5 day Drainage Rate	3	167,000	75
–With 4 day Drainage Rate	3	149,000	78
–With 3 day Drainage Rate	3	132,000	80
–With 2 day Drainage Rate			
Proposed 4 CSO/Year Tank			
–With 5 day Drainage Rate	6	243,000	65
–With 4 day Drainage Rate	6	220,000	67
–With 3 day Drainage Rate	5	190,000	71
–With 2 day Drainage Rate			

* CSO volume under existing conditions and CSO tank overflow volumes under proposed conditions.

APPENDIX G

TECHNICAL EVALUATION OF WOODWARD AVENUE WPCP CONTROL OPTIONS

APPENDIX G

TECHNICAL EVALUATION OF WOODWARD AVENUE WPCP CONTROL OPTIONS

Optimization of Present Plant

The following improvements to the present plant were investigated for steady-state conditions.

1. Full utilization of the aeration tank volume
2. Evaluation of the number of rotors in use on the North side aeration tanks. (Only 5 out of the 6 were in use in the summer-fall period of 1989 due to energy conservation objectives).
3. Optimization of the Sludge Residence Time (SRT) on the North side and the South side
4. Evaluation of the present flow split between the North side and South side (the split is approximately 2/3 – North, 1/3 – South)

The following improvements to present practices for dynamic conditions were evaluated.

1. Increasing sludge recycle without bypassing.
2. Application of step-feed.
3. Allocation of more flow to the south side during storm flows, since the south side was quite stable in terms of performance, even during the Hurricane Hugo storm.
4. Diversion of wasted solids directly to the digester rather than to the primary clarifiers (via the influent).

The results are described in detail in BEAK (1991); the pertinent findings relevant to the stormwater impact study are:

1. Optimization of SRT on the North and South side. The objective of optimization was to achieve significant nitrification during normal DWF but to keep MLSS as low as possible to minimize washout during storms. The simulations suggested the following operation conditions.
 - An SRT on the North side of approximately 8 d would keep MLSS low (2500 g/m³ and achieve significant nitrification (effluent calculated TKN values of 8 g/m³), and result in sludge wastage of approximately 1900 m³/d.

- An SRT on the South Side approaching 7 d would give partial nitrification. The model simulations evaluated the aeration tank capacity as a function of increasing MLSS; full scale trials in the direction suggested by the calculations are recommended to establish whether an SRT 7d is the appropriate target value for present operating conditions, in the plant.
2. For dynamic control in the present plant, the simulations indicated that application of step feed in an conjunction with allocation of 50% of the flow to the south side had the greatest performance benefit. But the degree of treatment was still inadequate relative to desired target levels of 25 mg/L suspended solids concentration. This statement is based upon the following calculated concentrations:

<u>Condition</u>	<u>Peak SS Concentration</u>
Hugo Hydrograph, No By Passing, and Increased Sludge Recycle	500 mg/L
Hugo; No By Passing; Step Feed	120 mg/L
Hugo; No By Passing, Step Feed on North Side, 50% of flow to South Side for 4 hours	80 mg/L

Baffling North Side Settlers and Application of Step Feed

Dynamic control in the present plant was next investigated using step feed in combination with improving the north side settlers. A range of flows were applied to the plant. The titles described in Table 1 for flow represent the following hydrographs:

- Hugo – The storm flow pattern of Hurricane Hugo
- 1.5 * Hugo – The Hugo Hydrograph multiplied by 1.5
- 2 * Hugo – The Hugo Hydrograph multiplied by 2.0
- "As Is 25 mm" – The hydrograph calculated to arrive at the plant from a uniform rainfall over the City with overflow devices set to present conditions in the fall of 1989.
- "All Flow, 25 mm" – The hydrograph from a 25 mm rainfall without any CSO discharges allowed to the Harbour.

TABLE 1

CALCULATED DYNAMIC PERFORMANCE OF HAMILTON WPCP

Flow Rates	Flow Hydrograph				
	Hugo	Flow 1.5 x Hugo	Flow 2 x Hugo	"As Is" 25 mm	"All Flow" 25 mm
Average Flow (MLD)	440	627	811	542	776
Peak Flow (MLD)	615	922	1230	1490	2210
Treatment Scheme	Daily Effluent Suspended Solids Concentration				
Existing Settlers; No Step Feed	114	294	306	310	317
Existing Settlers; Step Feed	35	233	279	250	297
Improved Settlers; No Step Feed	23	49	148	155	308
Improved Settlers; Step Feed	22	35	67	76	238

The treatment schemes examined included the following:

- Existing settlers – performance derived from directing all flow through the plant (i.e. no plant bypassing) but bypassing the primary clarifiers as per present operating policy and no improvement to the North Side settlers
- Improved settlers – direct all flow through the plant without any primary, secondary or plant bypassing, and improving the north side settlers (by baffling; better entry flow control, etc.) to give improved performance.
- Step Feed – application of step feed to the north side train. Note step feed cannot be applied to the South side in its present configuration because each unit is well mixed. The flow network would have to be modified to put 2 aerator tanks-in-series in order to allow step feed application.

The flow hydrographs represent a gradation in peak flow rates (see Table 1) from 615 MLD to 2200 MLD and a gradation in average daily flows from 440 MLD to 810 MLD. The 2 * Hugo scenario has a lower peak flow rate than the two 25 mm based hydrographs, but has approximately the same average daily flow rate (810 MLD) as the "All Flow, 25 mm" hydrograph (780 MLD). These average day flow rates are equivalent to the rate imposed on the plant if overflow volumes for control to one overflow/year were stored and fed to the plant over approximately 2 to 2.5 days.

The average suspended solids concentration in the plant effluent is given in Table 1 for each of the flow hydrographs and for 4 combinations of treatment schemes. Calculated concentrations for several other parameters, including BOD₅, ammonia, nitrate, and TKN are given elsewhere (BEAK, 1991).

The results indicate that the present plant could achieve effluent concentrations in the range of 25 mg/L with improved settlers and step feed, and would be within 50% of this value with step feed alone. However for flow patterns much above that of Hurricane Hugo, the present plant would be significantly above an effluent suspended solids concentration of 25 mg/L even if both step feed and improved North side settlers were used (see, for example, predicted effluent suspended solids concentrations for 1.5 * Hugo and larger flow hydrographs).

Other improvements in the present plant were examined, such as allocation of more flow to the South side for a short period. This has the effect of allowing the plant to handle somewhat larger storm related volumes. But these flow volumes are not substantial, relative to the plausible flows which would be directed to the plant with full implementation of a storage option designed to bring the overflow frequency to a lower level (4 overflows/year; 1 overflow/year) or to reduce the total overflow volume to values such as 10% of present discharge levels as suggested by the Hamilton Harbour Remedial Action Plan.

Accordingly, expansion options were next considered.

Expansion Options

A variety of expansion options were considered (BEAK, 1991) including:

- expansion of only the secondary settlers
- expansion of the primary and secondary settlers
- expansion of the primary and secondary settlers and aeration tank capacity (in the form of increasing the aeration coefficient)

The results are as follows:

1. Operating the plant in step feed mode, the final clarifiers, need to be expanded by 4 times in surface area if 1250 MLD enters the plant over the period of Hurricane Hugo. This flow volume is equivalent to the existing dry weather flow plus a stored volume of approximately 970 ML; or to the projected dry weather flow at 2025 of 420 MLD plus a stored storm volume of approximately 800 ML.

Note for this scenario of expanding the final clarifiers, new equalization storage in the system is not required, but expansion of the trunk mains, high lift pumps, and connecting channels in the Woodward Avenue WPCP is required.

2. Operating the plant in step feed mode, the final clarifiers need to be expanded by 60 % to maintain 20 mg/L SS in the effluent if the average flow rate originating from dry weather and

stored CSO sources is 600 MLD. This flow rate of 600 MLD is equivalent to present dry weather flow plus treatment of a stored volume of 970 ML over 3 days, or to the projected future 2025 dry weather flow of 420 MLD and treatment of 540 ML of stored CSO volume over a 3 days period. (The 540 ML is roughly equivalent to storage required to attain 4 overflows/year).

3. If the plant is not operated in step feed mode, a plant expansion involving doubling the area of both the primary and secondary clarifiers by 100% (i.e. doubling this surface area) and changing the aeration capacity on the South side such that the $K_L a$, the aerator coefficient is doubled, results in the following performance.
 - it adequately treats CSO stored water of 800 ML diverted to it over 3 days together with the 2025 dry weather flow rate of 420 MLD (Effluent concentrations from the primary tank are $BOD_5 = 60$ mg/L; $SS = 55$ mg/L; effluent concentrations from the secondary tank are $BOD_5 = 10$ mg/L; $SS = 25$ mg/L)
 - it is optimized to achieve nitrification (77–80% range with effluent concentrations of less than 2 g ammonia–N/L) and adequate residual dissolved oxygen (1 g/m³)
 - the MLSS values and sludge blanket heights are at safe levels

Summary of Expansion Options

- (a) A plant expansion of 50 percent for the primary and secondary settlers and changing of aeration system from mechanical aerators to diffused air systems would appear capable of achieving effluent suspended solids targets of 25 mg/L as a daily average when the expanded plant is operated in step feed mode for 3 days to handle present dry weather flows plus stored CSO volumes from an "1 overflow per year" rainfall work.

The expansion analysis is based upon the simulation which suggested that an expansion of the secondary clarifiers by 60% with step feed would achieve effluent target for suspended solids plus the practical rating of the present clarifiers (bypassing primaries at 380 MLD 85 IMOD) requiring an expansion of approximately 33% to handle the equivalent flow of 510 MLD (280 MLD of dry weather flow plus stored CSO volumes of 700 ML diverted to the plant over 3 days.

- (b) A plant expansion of 100% of primary and secondary settlers and expanding the aeration systems would appear capable of handling future dry weather flows plus treating stored volumes equivalent to one overflow per year, without using step feed. Based upon a screening level evaluation of the present south side aeration system, an expansion of the present south side aeration, tank surface area by 50% may meet the requirements. Conversion of the surface mechanical aerators to diffused aeration system may add also additional aeration capacity, but increase maintenance problems.

Accordingly, cost estimates are given for expanding the primary and secondary aerators by 100% and the aeration tanks by 50%.

APPENDIX H

CONSTITUENT LOADINGS

TABLE 1

CONSTITUENT LOADINGS TO HAMILTON HARBOUR/

COOTES PARADISE FOR VARIOUS CONDITIONS

Constituent	Total Daily Loadings in kg/day From CSO's, WPCP Discharges and Separated Stormwater Discharges For					
	Existing Conditions	Existing Level of Dev. With Recommended CSO and WPCP Remedial Works		Future Conditions With No Remedial Works	Future Combined With Recommended CSO, WPCP & Stormwater Remedial Works	
		4 CSO/Yr Control Strategy	1 CSO/Yr Control Strategy		4 CSO/Yr Control Strategy	1 CSO/Yr Control Strategy
SS	15,700	13,500	13,300	20,000	15,200	15,000
TS	186,000	183,000	182,500	240,000	235,000	235,000
TP	177	163	161	226	207	206
NH ₃	2,140	2,122	2,120	2,765	2,750	2,745
TKN	3,220	3,175	3,170	4,160	4,095	4,090
Zn	20	13	13	25	16	16
FC (counts/day)	3.6x10 ¹³	1.8x10 ¹³	1.6x10 ¹³	4.4x10 ¹³	2.3x10 ¹³	2.1x10 ¹³
BOD ₅	3,700	3,350	3,320	4,755	4,385	4,355
Pb	13	10	10	17	12	11
Cu	9	8	8	12	11	11

TABLE 2

CONSTITUENT LOADINGS TO HAMILTON HARBOUR/COOTES PARADISE

WITH A 4 CSO/YEAR CONTROL STRATEGY

(EXISTING CONDITIONS - TYPICAL YEAR 1989)

Constituent	CSO Loadings			WPCP Loadings			Stormwater Loadings		Total Loadings (Rounded)	
	Existing Conditions kg/day	4 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Existing Conditions kg/day	4 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Existing Conditions kg/day	Future Conditions With Wet Ponds kg/day	Existing Conditions kg/day	With Remedial Works kg/day
SS	2,715	353	200	6,950	7,115	900	6,000	-	15,700	13,500
TS	8,480	1,102		150,000	155,000		27,000	-	186,000	183,000
TP	17	2.2	5	140	141	60	20	-	177	163
NH ₃	30	3.9		2,086	2,097		21	-	2,140	2,122
TKN	76	9.9	20	3,058	3,079	530	86	-	3,220	3,175
Zn	7.9	1.0		3.1	3.2		9	-	20	13
FC (counts/day)	2.2x10 ¹³	2.9x10 ¹²		5.4x10 ¹¹	5.6x10 ¹¹		1.4x10 ¹³	-	3.6x10 ¹³	1.8x10 ¹³
BOD ₅	405	53		2,780	2,800		500	-	3,700	3,350
Pb	3.3	0.4		2.1	2.3		7.7	-	13	10
Cu	0.9	0.1		6.3	6.4		1.9	-	9	8
Overall Decrease or Increase In Constituent Loadings	-	87% Decrease	-	-	3% Increase	-	-	-	-	15% Decrease

TABLE 3

CONSTITUENT LOADINGS TO HAMILTON HARBOUR/COOTES PARADISE

WITH A 1 CSO/YEAR CONTROL STRATEGY

(EXISTING CONDITIONS - TYPICAL YEAR 1989)

Constituent	CSO Loadings			WPCP Loadings			Stormwater Loadings			Total Loadings (Rounded)		
	Existing Conditions kg/day	4 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Existing Conditions kg/day	1 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Existing Conditions kg/day	Future Conditions With Wet Ponds kg/day	Existing Conditions kg/day	With Remedial Works kg/day		
SS	2,715	135	200	6,950	7,130	900	6,000	-	15,700	13,300		
TS	8,480	424		150,000	155,000		27,000	-	186,000	182,500		
TP	17	0.9	5	140	141	60	20	-	177	162		
NH ₃	30	1.5		2,086	2,098		21	-	2,140	2,120		
TKN	76	3.8	20	3,058	3,080	530	86	-	3,220	3,170		
Zn	7.9	0.4		3.1	3.2		9	-	20	13		
PC (counts/day)	2.2x10 ¹³	1.1x10 ¹²		5.4x10 ¹¹	5.6x10 ¹¹		1.4x10 ¹³	-	3.6x10 ¹³	1.6x10 ¹³		
BOD ₅	405	20		2,780	2,800		500	-	3,700	3,320		
Pb	3.3	0.2		2.1	2.3		7.7	-	13	10		
Cu	0.9	0.1		6.3	6.4		1.9	-	9	8		
Overall Decrease or Increase in Constituent Loadings	-	95% Decrease	-	-	3% Increase	-	-	-	-	15% Decrease		

TABLE 4

CONSTITUENT LOADINGS TO HAMILTON HARBOUR/COOTES PARADISE

WITH A 4 CSO/YEAR CONTROL STRATEGY

(FUTURE CONDITIONS - TYPICAL YEAR 1989)

Constituent	CSO Loadings			WPCP Loadings			Stormwater Loadings		Total Loadings (Rounded)	
	Future Conditions kg/day	4 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Future Conditions kg/day	4 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Future Conditions kg/day	With Wet Ponds kg/day	Future Conditions kg/day	With Remedial Works kg/day
SS	2,715	353	200	9,035	9,220	900	8,200	5,600	20,000	15,200
TS	8,480	1,102		195,000	200,000		37,000	34,000	240,000	235,000
TP	17	2.2	5	182	183	60	27	22	226	207
NH ₃	30	3.9		2,710	2,720		25	23	2,765	2,750
TKN	76	9.9	20	3,975	3,995	530	111	89	4,160	4,095
Zn	7.9	1.0		4.0	4.1		13	11	25	16
FC (counts/day)	2.2x10 ¹³	0.3x10 ¹³		7.0x10 ¹¹	7.2x10 ¹¹		2.1x10 ¹³	1.9x10 ¹³	4.4x10 ¹³	2.3x10 ¹³
BOD ₅	405	53		3,610	3,630		740	700	4,755	4,385
Pb	3.3	0.4		2.7	2.9		11	8.2	17	12
Cu	0.9	0.1		8.2	8.3		2.8	2.3	12	11
Overall Decrease or Increase in Constituent Loadings	-	87% Decrease	-	30% Increase	33% Increase	-	39%	17%	28% Increase	7% Increase

TABLE 5

CONSTITUENT LOADINGS TO HAMILTON HARBOUR/COOTES PARADISE

WITH A 1 CSO/YEAR CONTROL STRATEGY

(FUTURE CONDITIONS - TYPICAL YEAR 1989)

Constituent	CSO Loadings			WPCP Loadings			Stormwater Loadings		Total Loadings (Rounded)	
	Future Conditions kg/day	1 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Future Conditions kg/day	1 CSO/Yr Control Strategy kg/day	RAP Objective kg/day	Future Conditions kg/day	With Wet Ponds kg/day	Future Conditions kg/day	With Remedial Works kg/day
SS	2,715	135	200	9,035	9,215	900	8,200	5,600	20,000	15,000
TS	8,480	424		195,000	200,000	-	37,000	34,000	240,000	235,000
TP	17	0.9	5	182	183	60	27	22	226	206
NH ₃	30	1.5		2,710	2,720	-	25	23	2,765	2,745
TKN	76	3.8	20	3,975	4,000	530	111	89	4,160	4,090
Zn	7.9	0.4		4.0	4.1		13	11	25	16
FC (counts/day)	2.2x10 ¹³	0.1x10 ¹³		7.0x10 ¹¹	7.3x10 ¹¹		2.1x10 ¹³	1.9x10 ¹³	4.4x10 ¹³	2.1x10 ¹³
BOD ₅	405	20		3,610	3,635		740	700	4,755	4,355
Pb	3.3	0.2		2.7	2.9		11	8.2	17	11
Cu	0.9	0.1		8.2	8.3		2.8	2.3	12	11
Overall Decrease or Increase in Constituent Loadings	-	95% Decrease	-	30% Increase	33% Increase	-	39%	17%	28% Increase	5% Increase

APPENDIX I
ADDITIONAL INFORMATION ON
CSO QUALITY CHARACTERISTICS

APPENDIX I

ADDITIONAL INFORMATION ON CSO QUALITY CHARACTERISTICS

The objective of this Appendix is to illustrate that CSO pollutant loadings may differ from those values reported in Section 6. To achieve this objective this Appendix will:

- briefly review the procedures used to define the event mean concentrations of the water quality constituents in CSO to illustrate that the adopted procedures are appropriate for a planning level study;
- highlight some of the processes which were not accounted for which may increase or decrease total loadings to Hamilton Harbour; and
- list a range of concentrations of the water quality parameters which may be expected in CSO.

The Appendix will conclude with an overview as to how the accuracy of the constituent loadings to Hamilton Harbour may be increased through additional studies.

Procedures and Assumptions in the Hamilton PCP Study

To determine the EMC of the water quality parameters in CSO, and the corresponding loadings to Hamilton Harbour, the procedure outlined below was used in the PCP study.

- EMC for the water quality constituents in sanitary sewage were based on observed concentrations at the Woodward Avenue WPCP.
- EMC for stormwater flows was based primarily on the widely used United States Environmental Protection Agency's National Urban Runoff Program (i.e. NURP) reports, and the experience of the study team with stormwater quality elsewhere in Ontario.
- The EMC of the water quality constituents in CSO were computed by the calibrated/validated SWMM4 model of the Region's combined sewer system. That is, the model considered: sanitary flows in the system (essentially constant during a storm event); stormwater flows (extremely variable) and the hydraulic characteristics of the CSO flow regulators to determine the water quality characteristics of CSO, and hence loadings to Hamilton Harbour.

This approach was taken since there exists very little observed data on the quality of CSO from the Region's combined sewer system. Therefore, it would be inappropriate to extrapolate CSO EMC data from other studies since:

- the quality of sanitary sewage in the Hamilton areas would be unaccounted for;
- the influence of the combined sewer system's hydraulic characteristics on CSO water quality would be ignored; and
- the influence of storm dynamics in the Hamilton area on the sanitary sewage/stormwater flow volumes would also be disregarded.

In summary, the procedures adopted in the current study incorporated known (i.e. sanitary sewage) data, representative stormwater quality data, the hydraulics of the combined sewer system, and the dynamics of rainfall events – rather than merely extrapolating data from other studies – to estimate the quality of CSO in the Hamilton area. The resulting loadings of SS, TP, etc., reported in Section 6 are, therefore, expected to be of the right order of magnitude.

Other Processes

The procedure outlined above for computing the quality of CSO, and hence CSO loadings, is thorough and appropriate for pollution control planning purposes. However, there exists other factors which were not accounted for in the study which may increase/decrease the loadings above/below those values presented in Section 6. An overview of these factors follows.

- The settling and resuspension of particles in the combined sewer system was not accounted for in the study. Settling of particles in combined sewer systems is common since combined sewers, which must be sized to convey peak stormwater flows, often have poor flow hydraulics during dry periods. As a result, particles which are usually held in suspension in sanitary sewage are often deposited on the invert of combined sewer system, only to be resuspended during runoff events. Consequently, a receiving body of water may be subjected to a "shock" loading if the resuspended particles are discharged to the receiving body as CSO, rather than to a WPCP for treatment. Within Hamilton, deposition of solids within the combined sewer system was observed during the flow monitoring/field inspection program

- This study lumped CSO at the major flow regulators, as the combined trunk sewer system, while CSO at more local flow regulators were ignored. It is the opinion of the study team that this assumption did not introduce large errors into the analysis.
- Sewer surcharging was not accounted for during the analysis. Based on the flow monitoring results and the study team's knowledge of the Region's combined sewer system, it is anticipated that the combined trunk sewers surcharge infrequently, while most of the Western Interceptor is expected to surcharge during large rainfall events (e.g. events greater than 15 mm). Under surcharged conditions in the Western Interceptor, it is anticipated that most combined sewage from the central business district would be discharged directly to Hamilton Harbour.
- The CSO analysis was conducted from May 1 to October 31, a period with frequent convective rainfall events (e.g. short duration, high intensity) which cause the greatest stormwater flows in the system. Hence, relatively low EMC for CSO resulted, since stormwater runoff is generally much weaker in strength than sanitary sewage (see Table 5.4). Had the analysis been expanded to incorporate the rest of the year, and hence less severe snow melt and frontal storm events (i.e. long duration, low intensity events), then stormwater flow magnitudes would be smaller on average. Consequently, CSO sewage strength is expected to be greater on an annual basis, than that which is reported here for the May 1 to October 31 period.

CSO EMC Reported in Earlier CSO Studies

Table 5.4 lists the EMC of the various water quality parameters as computed in this study, and as reported in earlier CSO studies. A review of Table 5.4 indicates that the results reported in this study are generally within the range of results reported in earlier studies, although usually at the lower end of the reported values. This trend may be the result of the characteristics of the Region's combined sewer system, or it may be a result of not accounting for deposition/resuspension, etc.

The values in Table 5.4 are useful as they may be used to provide alternative planning level estimates of loadings to Hamilton Harbour. For example, if the median ammonia EMC value from the Woodward Clyde reports is assumed to be representative of the study area (i.e. a concentration of 1.9 rather than 1.3 mg/l), then an alternative estimate of the ammonia loading would be approximately 46 percent greater than that which was reported in Section 6. Similar estimates could also be prepared for the

TABLE 5.4
EMC DATA FOR SANITARY SEWAGE,
WPCP EFFLUENT, STORMWATER RUNOFF

Parameter	Sanitary Sewage EMC (mg/l)	WPCP Effluent EMC (mg/l)	Stormwater Runoff EMC (mg/l) Urban Areas	Stormwater Runoff EMC (mg/l) Rural Areas
SS	302	20	100	150
TP	6.0	0.4	0.33	0.46
Ammonia	14	6	0.3	1.2
TKN	27.4	8.8	1.35	2.84
Zinc	2.6	0.009	0.16	0.006
FC (#/100ml)	1 x 10 ⁶	100	25,000	1,000
DS	430	430	350	390
BOD ₅	129	8	9.00	2.0
Lead	0.071	0.006	0.14	0.004
Copper	0.10	0.018	0.034	0.004

NOTES:

- EMC data was obtained through:
Analysis of STP influent and effluent.
NURP or Woodward-Clyde Reports.
Observed stormwater flows from urban areas throughout Ontario.
Rural stormwater flows observed in the Picton area.
MOE's "Technical Guidelines for Preparing a Pollution Control Plan."
A review of the Woodward Avenue WPCP's Certificate of Approval.

other water quality parameters to determine a range of possible loadings of the parameters to Hamilton Harbour.

Summary

In summary, the planning level methods applied in this study to ascertain constituent loadings to Hamilton Harbour were based on observed data and reasonable assumptions. The loadings presented in Section 6 are, therefore, expected to be of the right order of magnitude. However, various processes/conditions which may influence constituent loadings were not accounted for and hence actual loadings to Hamilton Harbour may differ from those presented here. To provide additional insight into the range of loadings which may be anticipated, this Appendix has presented a range of EMC data for CSO.

If it is required to increase the accuracy of the constituent loadings to Hamilton Harbour, then it is recommended that a long-term CSO quantity/quality monitoring program be adopted. The program should span at least one calendar year so that CSO quantity/quality characteristics for various types of runoff events (e.g. melt events and thunderstorms, etc.) could be determined. Large runoff events (e.g. greater than 12 mm) are the key events that would have to be monitored during the program since such events are estimated to contribute at least 60 percent of the CSO volume/loading to Hamilton Harbour. It is also recommended that CSO quantity/quality monitoring be conducted at a minimum of 4 outfalls to determine representative CSO characteristics throughout the Region.

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